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A Discontinuous Galerkin Spectral/ hp Method for high order Boussinesq equations

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A new high order Boussinesq method for fully nonlinear waves from shallow to deep water was developed by Madsen *et al.* [1]. This method is capable of accurately modeling nonlinear water waves right up to the point of breaking for relative water depths up to $kh \approx 40$, (k the wavenumber and h the water depth) also providing accurate kinematics for the vertical variation of the flow up to $kh \approx 12$. For the method to be efficient, the solution effort of any numerical scheme for solving these Boussinesq equations should ideally scale with the number of unknowns in the problem - in which case the method provides an efficient means for modeling a broad range of water-wave phenomena in the near-coastal environment.

In this talk, we present a Discontinuous Galerkin spectral/ hp element method for solving the new high order Boussinesq equations. The goal of the current work is to develop a method for solving these Boussinesq equations, which is accurate, efficient and in particular offers geometric flexibility - properties which are offered by the Discontinuous Galerkin spectral/ hp method. An existing high order Finite Difference method based on a piecewise rectangular grid does not offer such geometric flexibility and therefore it is our goal that by this new approach, we will be able to resolve problems in complicated harbor and coastal regions. For the discretization of the presented method, we use a method of lines approach where the spatial discretization is based on the Discontinuous Galerkin spectral/ hp element method and for advancing in time we use a 4th order explicit Runge-Kutta method.

We shall give a description of the Discontinuous Galerkin spectral/ hp method for solving these new high order Boussinesq equations in both two and three dimensions. Further, we will discuss means of generating and absorbing waves inside the computational domain by a line source method. Finally, we present some results demonstrating spectral convergence of the presented method and some results for comparison with known test problems from the literature.

References

- [1] Madsen, P.A., H.B. Bingham, and H. Liu. A new Boussinesq method for fully nonlinear waves from shallow to deep water. *J. Fluid Mech.* 462, 1–30, 2002.